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(12) # APPLICATION OF EUROPEAN PATENT

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(54) **Plate exchanger made up with modular elements composed of two identical rectangular plates and a solid sheet.**

(57) The present invention relates to a molded modular element.

This module comprises: a first and second plates made of molded material (11, 12) each made up with a flat frame (110, 120) delimiting a central opening (111, 121) inside of which there are threads (112, 122), orifices being arranged in the frames (110, 120) for circulating fluid, a solid thin sheet (13) placed between the first and the second plates (11, 12), means for keeping both plates against each other, said solid sheet (13) is placed between the plates.

Application to plate heat exchangers, to infiltration, to osmosis and to other separation processes using membranes.

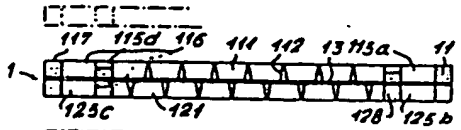

FIG.2

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The present invention relates to a plate exchanger made with simple concept of molded material and cost saving manufacturing, made up with a stacking of modular elements particularly easy to dismantle and to re-install for cleaning.

Heat exchangers are apparatuses which allow one to run a thermal flux of a fluid toward another. Plate exchangers are particularly advantageous exchangers due to their simplicity, their very good exchange coefficient, their easy maintenance, their compactness and the possibility of varying the exchange surface without modifying the frame. Such apparatuses are made up with a stacking of assembled flat elements to delimit separated flowing circuits run by the fluids, respectively fluids with different temperatures between which the heat exchange is performed.

Many embodiments of plate exchangers are known.

According to the first type of known embodiment, flat elements are made up with pressed metallic plates and comprising grooves to create a turbulent flowing regimen, and pressed close to each other. Joints are placed between plated to assure the sealing.

According to a type of embodiment, described, for example, in the patent No. 74 36882 deposited in the name of the "Commissariat à l'Energie Atomique", for "Plate exchangers", the exchanger with plates is made up with a stacking of thin, solid sheets, kept together with spacing plates in the form of frames delimiting a central cavity. Orifices arranged in the frame determine circuits in which circulate two fluids. Heat exchange is done through the thickness of said thin sheets.

This embodiment is advantageous. In fact, it is possible to reduce the thin sheet thickness to few hundredths of millimeter. So, notwithstanding the plastic bad conductivity, the exchange coefficient is reduced with respect to the traditional plate exchangers.

Spacing frame may be advantageously made of molded plastic material. So, a plate exchanger is obtained with a simple concept, without joint, reduced bulkiness, having a good thermal exchange coefficient. Moreover, it is possible to change the exchange surface due to its low cost.

However, exchangers of this type is difficult to maintain and to clean. In fact, it is known that it is necessary to periodically dismantle the plate exchangers in order to remove deposits which are accumulated during its operation. This care is much more necessary if a grid or another similar device is found inside the central cavity, said grid or similar device designed for creating a turbulent fluid flow in order to facilitate the heat exchange whose several angles are favorable for the formation of deposits. When dismantling the exchanger, the thin sheet or the grid is no longer kept in place by the spacing frames. The result is a difficulty for dismantling and re-installing the exchanger. Particularly, it is necessary for this type of apparatus to stack the flat elements and to press them close between two end plates before being able to put the apparatus back to its normal operation position, or to leave it in horizontal position. Even in this position, the maintenance is less easy than for the first type of known embodiment.

Precisely, the invention subject is a plate exchanger having the above described advantages. In addition, it offers a certain number of additional

advantages.

This exchanger is composed of a stacking of modular elements. It is possible to manufacture the set of modular elements by means of a single mold. Each modular element is made up with a plate molded made out from a single mold, and an identical plate turned 180° around its median longitudinal axis A, a solid sheet being placed between and pressed against the two frames.

It is possible to mold into one single piece, the frame, the spacing frame and the grid of the central cavity, this was not possible with the previous technique of plate construction. In addition to the resulting simplicity advantage, the plate mechanical performance is largely improved.

The exchanger of the invention allows one to dismantle and particularly to easily re-install the apparatus. In fact, each solid sheet is kept in permanence by two frames pressed against each other. Each modular element thus forms a rigid set which has good performance and therefore easy to be handled.

On the other hand, given that the fluid arrival and evacuation are dug into only one surface of each frame, they are exposed and by this fact can be easily cleaned, for example, by means of water jet. It is a great advantage, particularly in the case of food industry.

More precisely, plate exchanger of the invention, which is made up with a stacking of modular elements pressed close between two end plates delimiting two separated flowing circuits wherein circulate two fluids exchanging heat, the stacking being alternatively made up with a modular

element and another identical modular element turned 180° with respect to one of its axes. It is characterized by the fact that each modular element is composed of two identical rectangular plates made of molded material respectively named first and second plates and a solid sheet, each plate being made up with a flat frame which has a median longitudinal axis A and a median transverse axis B, the frame delimiting a central opening, inside of which there are parallel threads, in one piece with the frame, and having a thickness roughly equal to that of the frame, these threads being such that by turning a modular element around one of its axes B with respect to the adjacent element, it is possible, by stacking them together, to determine the fluid circulation paths, open fluid arrival and evacuation canals being dug into one of the frame surfaces, this fact allows an easy cleaning of the exchanger, the other surface of the plate being flat, said second plate being turned 180° around its median axis A before being coupled to the first plate, their flat surfaces being back-to-back, the solid sheet being placed between said first and second plates, completely and continuously covering the central cavity of each plate, modular element comprising in addition means for keeping said first and second plates pressed against each other, such that the solid sheet is permanently kept in place.

According to a variation of the embodiment, modular elements which make up the exchanger of the invention may be made up with two identical plates or with different plates. The differences between these two plates may be from:

- the angle, the density or the form of the threads making up the grids,
- the frame thickness,
- the diameter of fluid feeding orifices and the form of distribution zones.

Thus, it is possible to perform the exchange between two fluids having different flow rates or very different thermodynamic properties. It is also possible to make counter-flow or co-flow heat exchanger.

Preferably. the plate is made out of a plastic material.

Preferably, thin film is made of Teflon, polypropylene, or stainless metals, very resistant materials, relatively not much expensive due to the small thickness and allowing one to use very corrosive fluids.

Moreover, the thin film may be made up with a superposition of two different films, such as with plasticized metal, or with two superposed films, one made of metal, the other plastic.

According to a particular embodiment, plate exchangers of the invention comprises four orifices, the centers of which are symmetrically placed with respect to both axes A and B arranged in the frame, two of these orifices, placed on both sides of axis B, being linked to the central opening with canals dug into one of the frame surfaces, and the other two orifices not communicating with the central opening.

According to another embodiment, plates of the invention exchanger are square and shifted 90° angle with respect to each other.

According to a third embodiment, the invention exchanger comprises a first and a second plates, the first plate comprising two orifices linked to the central opening with canals dug into one of its surfaces for the liquid circulation, the second plate comprising two orifices which do not link to the central opening, and on its longitudinal edges, a series of orifices for the circulation of a gas.

Other characteristics and advantages of the invention will appear with the description of the following examples of the invention embodiment, given as indication and non limiting, with reference made to annexed drawings, wherein:

– figure 1 is a top view of a modular element. The stacking of several of these modular elements makes up the plate exchanger of the invention;

– figure 2 is a cross-sectional view of the modular element of figure 1;

– figure 3 is a detailed view of the modular element shown in figure 1, for two possible positions of the films;

– figures 4a and 4b are two cross-sectional views of a plate heat exchanger in compliance with the present invention;

– figure 5 is a variation of the modular element shown in figures 1 to 4;

– figure 6 is a third embodiment of the modular element adapted to a gas-gas exchange with cross currents;

– figure 7 shows a modular element made up with two plates, one of which is planned for the liquid circulation and the other for the circulation of a gas;

– figure 8 is an exchanger made up with several types of plates.

Plate exchanger of the invention is made up with a stacking of modular elements pressed against each other between two end plates for delimiting two separated flowing circuits traveled through by two heat exchanging fluids and kept pressed between an upper end plate and a lower end plate.

Figure 1 is a top view of one of these modular elements 1. First, we will describe the structure of the modular element with reference made to figures 1 to 3. Then, with reference made to figures 4a and 4b, the way these elements are assembled to form the plate exchanger of the invention.

Modular element 1 is composed of a first plate 11 made of molded plastic material, a second plate 12 also made of molded plastic material and a thin sheet 13, solid and sealed, made of plastic or metallic material, placed between plates 11 and 12. Module 1 comprises, in addition, means, such as clips, for keeping plates 11 and 12 against each other.

First plate 11 appears in solid lines, while the lower plate 12 appears in mixed lines.

First plate 11 is made up with flat frame 110 which has a median longitudinal axis A and a median transverse axis B perpendicular to A, and delimits a central opening 111 inside of which parallel threads 112 slanted with respect to axis A respectively connects both longitudinal edges 113 and 114 to frame 110. Four orifices, referenced as 115a to 115d, symmetrically placed with respect to both A and B axes, are arranged in frame 110. Two of these orifices 115a and 115d, placed on the same side of A axis, are linked to the central opening 111 with canals 116, radially placed from orifices 115a and 115d, establishing a lengthwise communication without leaving any empty space for the fluid between the central opening and each one of the orifices 115a and 115d. This absence of empty space allows having a maximal use of the exchange surface and a possibility of chemical cleaning without dismantling the exchanger.

Orifices 115b and 115c do not communicate with the central opening 111.

The whole plate 11 may easily be made in one piece of molded plastic material, including parallel threads 112.

Plate 11 may also be obtained with soldering of molded elements, inn order to make a very long exchanger.

Modular element 1 according to the invention comprises a second plate 12 made of molded plastic material, placed under the first plate 11. This second plate 12 shown in mixed line is identical to the first plate 11. It is simply turned 180° around its axis A before being coupled to the first plate 11. Thus, this plate 12 comprises four orifices, respectively 125a to 125d which are superposed to orifices 115a to 115d of plate 11. Orifices 125a and 125d of plate 12 communicate with its central opening 121 through canals dug into one of its surfaces. The other two orifices 125b and 125c do not communicate with this central opening 121. As the plate 12 is turned over, orifices 115a and 115b of plate 11 coincide with orifices 125b and 125a of plate 12, while orifices 115d and 115c of plate 11 communicate with orifices 125c and 125d of plate 12.

It is possible to noted that the inclination of parallel threads 122 of plate 12, obliquely placed with respect to axis A have an inverse inclination of threads 112 and therefore cross them. It is these crossing points which keep a spacing between films and cause the turbulent regimen.

Thin sheet 13 placed between plates 11 and 12, is solid and sealed. Sheet 13 covers the entire central opening 111, and lightly exceeds it such to be pinched between plates 11 and 12, as it can be seen in figure 3a.

This arrangement assures the sealing between both flowing circuits. In the event that sheet 13 is too thick, i.e. in the event that its thickness is greater than about 0.1 mm., the entire set sealing can not be assured as shown in figure 3a. That is why sheet 13 covers the entire surface of modular element 1, as shown in figure 3b. Four orifices are made in sheet 13 facing orifices 115a to 115d (125a to 125d) of plates 11 and 12.

It is shown in figure 2 a cross-sectional view along the line III-III in figure 1 of the modular element 1. In this figure, it is particularly noted that orifice 115a of plate 11 is superposed to orifice 125b of plate 12, and orifice 115d of plate 11 superposed to orifice 125c of plate 12. So, one of the plates of module 1, eventually plate 11, allows the communication with central opening 111, while the communication with central opening 121 of plate 12 is impossible.

A cross-sectional view along the line III-III in figure 1 of a series of modular elements 1 according to the invention, is shown in figure 4a. the elements are arranged for delimiting two separated flowing circuits to make up a plate heat exchanger in compliance with the invention. In order to delimit two separated flowing circuits, modules 1 placed in the position they occupy in figure 2, are alternatively coupled with modules 1 designated with reference number 1_i in figure 5a, after being turned 180° around their axis B. In the following part of the text, module 1_i parts will be designated with the same references as those of module 1, followed with index i. Thus, between two successive thin sheets 13, it is found either two surfaces, respectively 117 and

117_i wherein fluid circulation canals are dug, respectively 116 and 116_i, or on the contrary two surfaces comprising no circulation canals, respectively 118 and 118_i. So, a series of cavities 220, 221, 222, 223, 224 are delimited, these cavities which alternatively communicate then do not communicate with canals 117 and 118. Cavities 221, 223, ... which communicate with canals 117 and 119 determine a first circuit for the first fluid, for example cold fluid 38. Inside of cavities 220, 221, 222, 223, 224, there are parallel threads 112 and on the other hand threads 122. These threads which cross themselves cause the turbulence which improves the heat transfer. Another advantage of these threads is to contribute to the exchange resistance by maintaining longitudinal edges, such as 113 and 114, these edges having a tendency of getting away by the pressure effect of the fluids circulating in the exchanger. They also maintain a constant spacing between thin sheets.

According to a variation of the embodiment, parallel threads 112 and 122 are perpendicular to the longitudinal axis of the modular element. This arrangement is the one which maintains better longitudinal edges 113 and 114. In this variation, spacing is such that during the turning over of plate 12 with respect to plate 11, threads of plate 12 come to place themselves between threads of plate 11, this fact produces a series of obstacles, such as those shown in figure 4a. In this variation, there are in addition threads parallel to axis A which, during the turn over of plate 12, exactly coincide with their homologues of plate 11 and work as cross-pieces. An advantage of having threads which cross themselves at the level of each plate is to facilitate their molding.

Figure 4b shows a cross-sectional view of the plate heat exchanger

shown in figure 4a, along the line IV-IV in figure 1. As it is possible to noted in this figure, the superposition of orifices 115b and 115c of plates 11 and orifices 125a and 125d of plates 12, determines two other circulation canals, respectively 119 and 120 for a second fluid, for example hot fluid 40. Fluid 40 travels through cavities designated with reference numbers 220, 222, 224, while the cold fluid 38 travel through cavities 221, 223. Thus, calorie exchange of hot fluid 40 to cold fluid 38 is done across thin sheets 13. These thin sheets can be made from plastic or metallic material. They may be especially made out with polytetrafluorethylene or with stainless metals. Their thickness is ranging between 0.05 and 1 mm. Thus, it allows having an excellent heat exchange coefficient.

It is noted that plate exchanger described in figure 4 anticipates a counter-flow circulation of fluids 38 and 40. Naturally, according to a variation of the embodiment, it would be possible to provide a co-flowing circulation of these fluids.

The stack of modules 1 and 1_i is maintained by two end plates such as plate 4 shown in figure 1, made of steel or another appropriate material, in one piece with each other with ties (not shown) perpendicularly extending to the plane of modular elements 1 and 1_i, thus assuring an easy dismantling for maintenance or a change of one or several modules.

According to a variation of the embodiment, each module may be made up with two plates having different thickness. The flowing is thus determined for different cross-sections, this fact allows one to adapt the exchanger to different flow rates for both fluids.

An essential advantage of the plate exchanger made in compliance with the invention is that in case of dismantling, for example, for the purpose of its cleaning, thin films 13 are maintained between frames 110 and 120 of the modular element with a sprocket interlocking system and eventually, with other means, such as clips. This characteristic allows one to easily dismantle then to re-install the exchanger, indifferently in horizontal or vertical position.

The exchanger according to the invention may be made out by joining end-to-end molded elements of the central opening 111, in order to make up a very long exchanger.

Modular element according to the invention is also used for osmosis (direct or inverse), for dialysis, for filtration and for ultra-filtration. In these cases thin film 13 is no longer sealed, but is made up with a membrane adapted to the searched function.

A variation of the embodiment of the modular element shown in figures 1 to 4, is shown in figure 5. This modular element is made up with two plates, plate 11' and plate 12'. However, contrarily to the previously described embodiment, plates 11' and 12' are not identical. They are made out from two different molds. As one can observe, the diameter of fluid feeding orifices is different. In the case of plate 11', diameter of orifices 115'a and 115'd is greater than that of orifices 115'b and 115'c. It is the same for the corresponding orifices of plate 12'.

It is also noted that threads making up the grids of these two plates are different. For both plates, the longitudinal threads play the role of a cross-

piece for the thin sheet. In return, transverse threads are slanted in the case of plate 11', while they are perpendicular to longitudinal threads in the case of plate 12'.

A third embodiment of the module according to the invention is shown in figure 6. Both plates of this modular element are identical. Consequently, they are made out from a single mold. Plate 12" which is square, is simply rotate 90° with respect to plate 11", before being coupled to the latter.

This exchanger is used for pre-heating combustion air with corrosive smoke, the air current 50 circulating, for example horizontally, as shown in figure 6, while corrosive smoke circulates upward, as shown at 52.

A fourth embodiment of the modular element according to the invention is shown in figure 7. This modular element is composed of a first plate 11"' intended for the liquid circulation and a second plate 12"' for gas circulation. Plate 11"' comprises two circular orifices 115"'a and 115"'d linked to the central opening 111"' with canals dug into one of its surfaces. Plate 12"' comprises two plates 125"'b and 125"'c which do not communicate with the central opening 121"' of the plate, and on its longitudinal edges a series of orifices 54 for the gas circulation. In plate 11"', fluid circulation is done in the transverse directions. Thus, a cross current circulation is done.

Such exchanger may be used for heating water intended for the heating of premises using heat contained in the corrosive smoke.

According to another application, this exchanger may be used for making up an automobile radiator.

For application to automobile or household electrical appliances, this exchanger may be completely soldered.

Finally, an exchanger made by assembling several types of plates are shown in figure 8. Thus, the exchanger shown in this figure comprises three different types of plates.

CLAIMS

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1. Plate exchanger similar to those which are made up with a stacking of modular elements (1), pressed against each other between two end plates for delimiting two separated flowing circuits wherein both fluids circulate while exchanging heat, the stacking being alternatively made up with a modular element and an identical element turned 180° with respect to one of its axes, characterized by the fact that each modular element (1) is composed of two identical rectangular plates made of molded material respectively named first and second plates (11, 12), and a solid sheet (13), each plate (11, 12) being made up with a flat frame (110) which has a median longitudinal axis A and a median transverse axis B, frame (110) delimiting a central opening (111), inside of which there are parallel threads (112), in one piece with the frame and having a thickness roughly equal to that of the frame, these threads (112) being such that by turning over a modular element (1) around one of the axes B with respect to the adjacent element and by stacking them, it is possible to determine the circulation path for the fluids, the open canals (116) for fluid arrival and evacuation being dug into one of the surfaces (surface 117) of frame (110), this fact allows an easy cleaning of the exchanger, the other surface of the frame being flat, said second plate (12) being turned 180° around its median axis A before being coupled to the first plate, their flat surfaces back-to-back, solid sheet (13) being placed between said first and second plates, completely and continuously covering the central opening (111) of each plate, modular element (1) comprising in addition means for maintaining said first and second plates pressed against each other, such

that solid sheet (13) is permanently kept in place.

2. Plate exchanger similar to those which are made up with a stacking of modular elements (1), pressed against each other between two end plates for delimiting two separated flowing circuits wherein two fluids circulate while exchanging heat, the stacking being alternatively made up with a modular element and an identical modular element turned 180° with respect to one of its axes, characterized by the fact that each modular element (1) is composed of two rectangular plates made of molded material, respectively named first and second plates (11, 12), and a solid sheet (13), each plate (11, 12) being made up with a flat frame (110) which has a median longitudinal axis A and a median transverse axis B, frame (110) delimiting a central opening (111) inside of which there are parallel threads (112), in one piece with the frame and having thickness roughly equal to that of the frame, these threads (112) being such that by turning over a modular element (1) around one of its axes B with respect to the adjacent element, it is possible to determine, by stacking them, the circulation path for the fluids, the open canals (116) for fluid arrival and evacuation being dug into one of the surfaces (surface 117) of frame (110), this fact allows one to have an easy cleaning of the exchanger, the other surface of the frame being flat, said second plate (12) being coupled to the first plate, their flat surfaces back-to-back, the solid sheet (13) being placed between said first and second plates, completely and continuously covering the central opening (111) of each plate, in addition modular element (1) comprising means for maintaining said first and second

plates pressed against each other, such that solid sheet (13) is permanently kept in place.

3. Exchanger according to any one of claims 1 and 2, characterized by the fact that said solid sheet (13) is made of plastic, metallic or mixed material, having a thickness ranging between 0.05 and 1 mm.

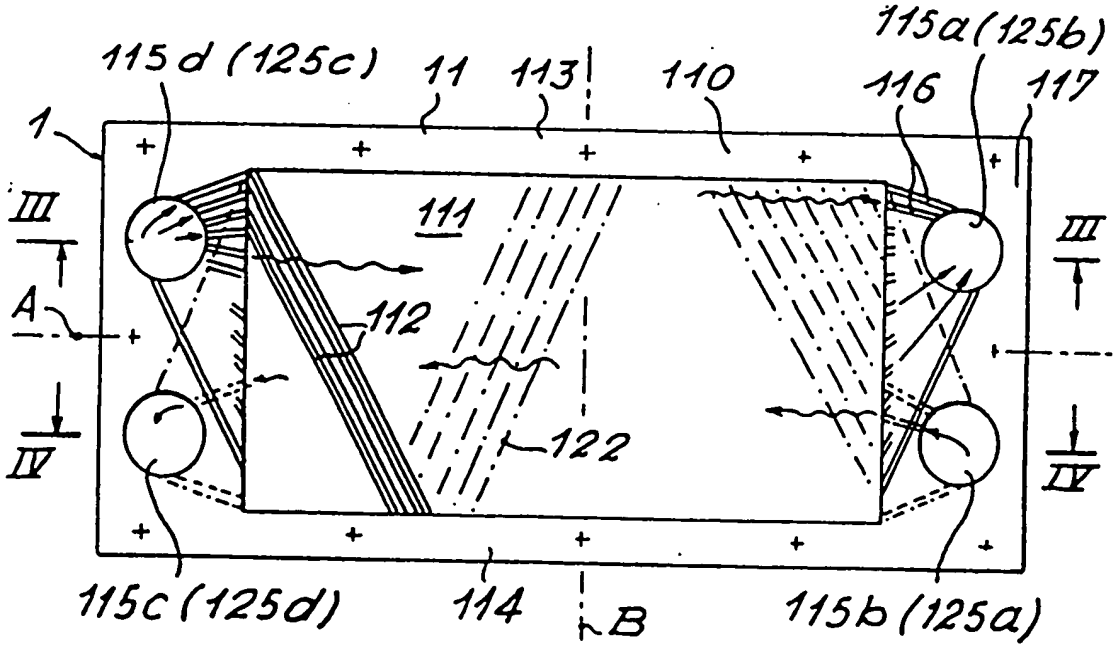
4. Exchanger according to any one of claims 1 to 3, characterized by the fact that plates (11, 12) are made of plastic material.

5. Modular element according to any one of claims 1 to 4, characterized by the fact that each plate comprises four orifices (115a, 115b, 115c, 115d) whose centers are symmetrically placed with respect to both axes A and B arranged in said frame (110), two of these orifices (115a and 115d) placed on both sides of axis B being linked to said central opening (111) with canals (116) dug into one of the surfaces (surface 117) of frame (110), the other two orifices (115b and 115c) having no communication with the central opening (111).

6. Exchanger according to any one of claims 2 to 4, characterized by the fact that plates (11', 12') are square and shifted 90° angle with respect to each other.

7. Exchanger according to any of claims 2 to 4, characterized by the fact that it comprises a first and second plates (11"', 12"'), first plate (11"') comprising two orifices (125"'a, 125"'d) linked to the central opening (111"') with canals dug into one of its surfaces for the circulation of a liquid, second plate (12"') comprising two orifices (125"'b, 125"'c) which do not communicate with the central opening (121"') and having on its longitudinal edges, a series of orifices (54) for the circulation of a gas.

FIG.1


115d (125c)
11
113
110
115a (125b)
116
117
1
III
A
IV
111
112
122
III
IV
115c (125d)
114
B
115b (125a)

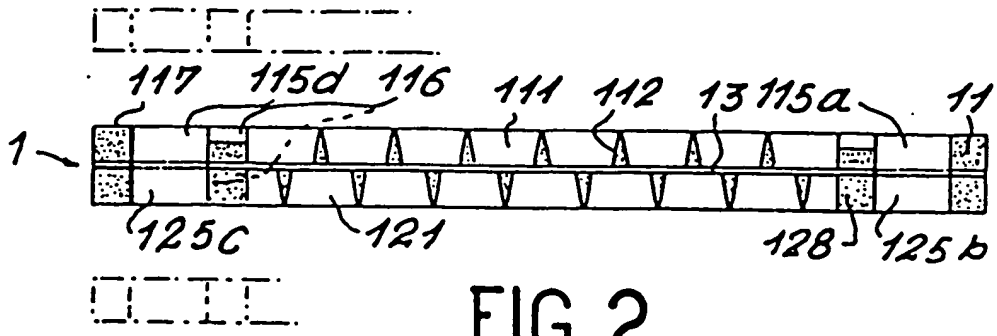


FIG. 2

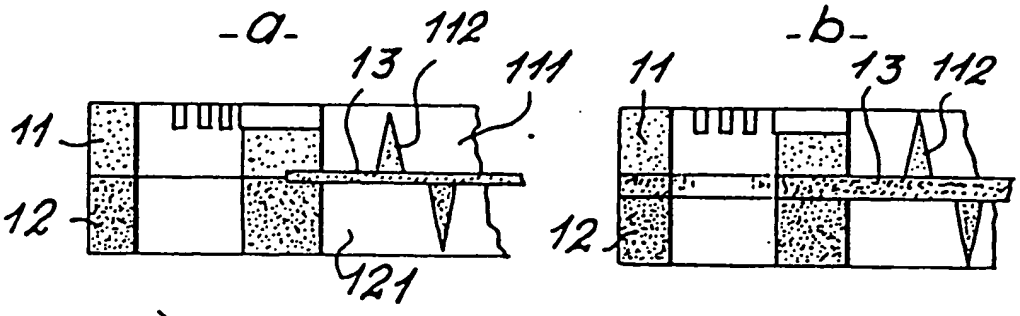


FIG. 3

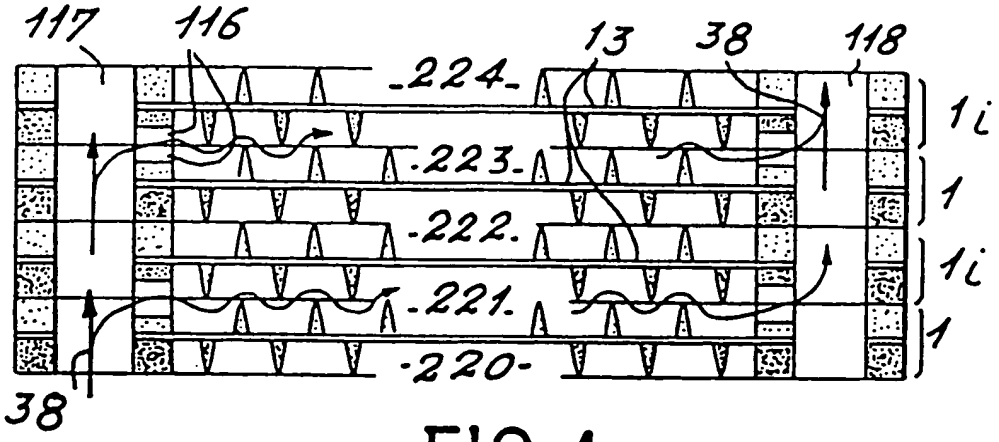


FIG. 4a

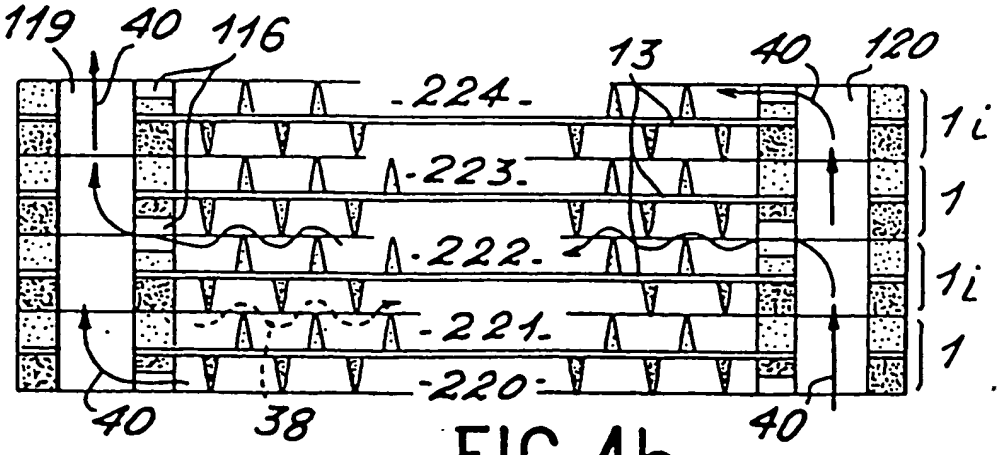
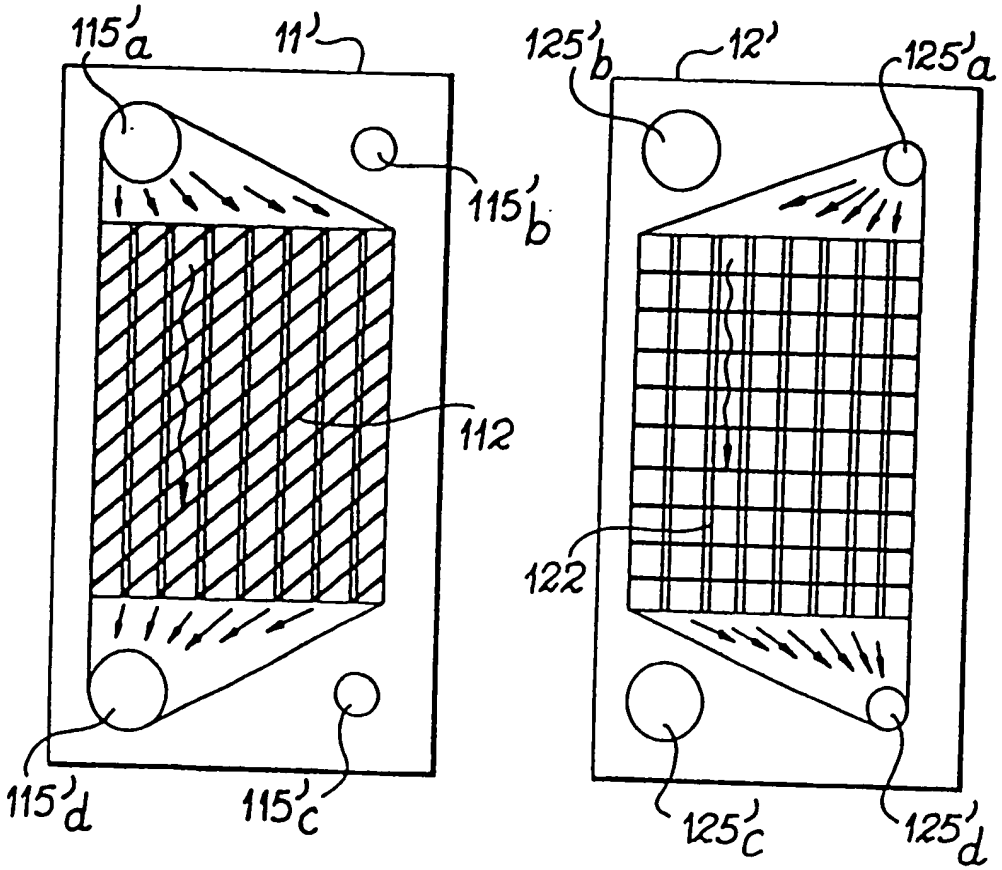


FIG. 4b

FIG. 5


115'a
11'
115'b
112
115'd
115'c
125'b
12'
125'a
122
125'c
125'd

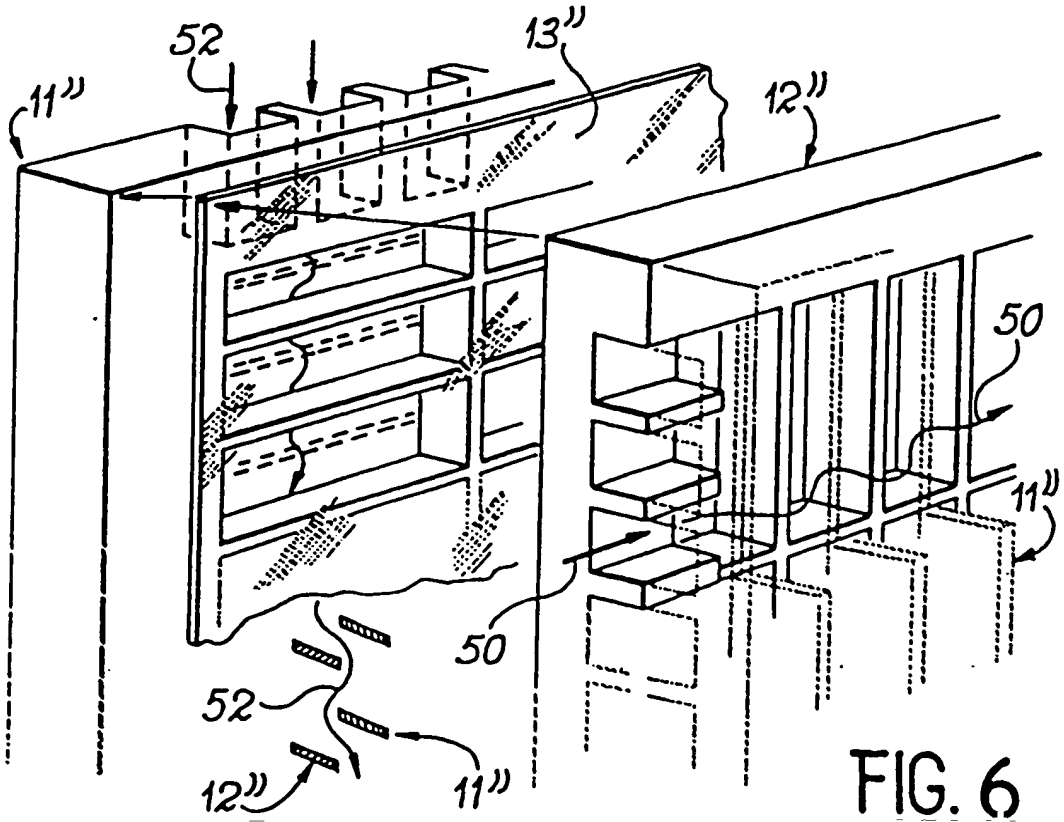

52
13"
11"
12"
50
11"
50
52
12"
11"

FIG. 6

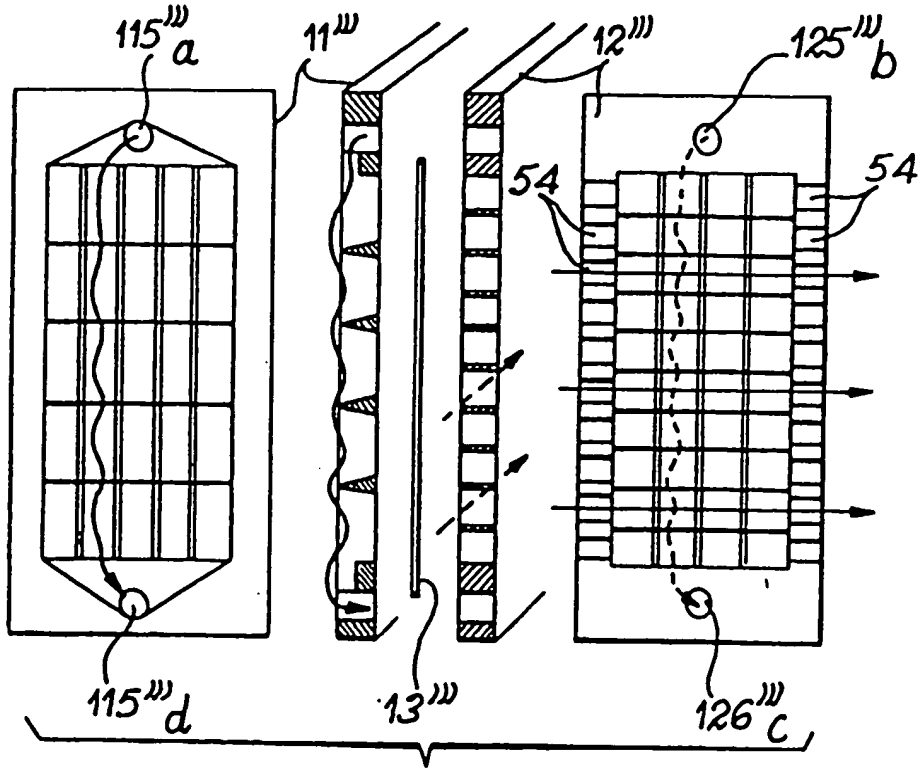


FIG. 7

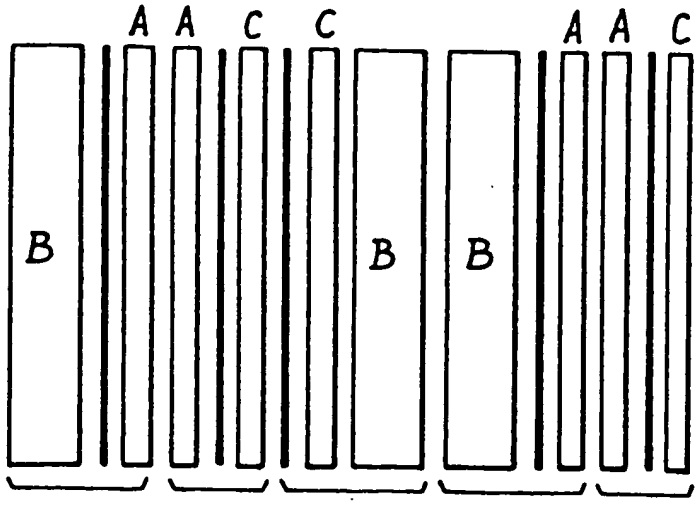


FIG. 8

European Patent Office

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EUROPEAN SEARCH REPORT

Application No.

EP 81 40 0655

DOCUMENTS CONSIDERED AS RELEVANT			APPLICATION CLASSIFICATION (Int. Cl.[5])
Category	Citation of document, with indication, where appropriate, of the relevant parts	Relevant to claim No.	
X	FR-A-2 290 646 (C.E.A.) * Entire document *	1-5	F 28 F 3/08 21/06
X	FR-A- 997 591 (CREAMERY PACKAGE) * Page 1, lines 16-49; Page 2, left column, lines 9-32; page 4, left column, lines 9-25; figures 2, 10 *	1-3, 5	
	FR-A-2 184 536 (A.N.V.A.R.) * Page 2, line 31 - page 3, line 14 - page 4, paragraph 1; page 5, line 24 - page 6, line 14; figure 1 *	1-5	SEARCHED TECHNICAL FIELDS (Int. Cl.[3])
	FR-A-2 175 804 (PHILIPS) * Page 4, line 7 - page 5, line 15; figure 1 *	1-3, 5	F 28 F F 28 D
	FR-A-2 314 461 (DIEU) * Page 2, lines 23-39; figure 6 *	6	
	DE-A-1 930 815 (AIR PREHEATER-COMP.) * Page 4, lines 12-21; Page 6, last paragraph; page 7, first paragraph; Page 8, claim 1; figure 4, 5 *	7	
			CATEGORIES OF CITED DOCUMENTS
			X: particularly relevant by itself A: technological background O: non-written distribution P: intercalary document T: theory or principle at the base of the invention E: interfering application D: cited in the application L: cited for other reasons
X	The present report was established for all claims		&: member of the same patent family, corresponding document

Place of search	Search completion date	Examiner
LA HAYE	AUGUST 7, 1981	SCHOUFOUR